November 9, 1984

Pinnacle Engineering Co. P.O. Box 527 228½ Main, Suite C Hamilton, Montana 59840

Dear Jim:

Enclosed is the plezometer data for No. 3 tailings pond collected between January 1979 and November 1984. A summary sheet for each year contains all water levels plus slimes and pond surface water.

Note at each station there are two crest wells; one at approximately 60 feet in depth, the second at 40 feet. The most active well appears at station 17+00 located at the northeast corner. The piezometers at the northwest corner and center north dike have been buried since the summer of 1981. Therefore, no data is available beyond this date.

Robert J. Hitt Engineering Supervisor BEKER INDUSTRIES CORP.

RJH:krj

encl:



WATER ELEVATIONS

4 ₹	1834N	1 FEB	14 FEB	I MAR	15MAR	31 MAR	IS APR	I MAY	17 MAY	J JIWE	15 JANE	l Jucy	יאבאינ	1Aug	15 Aug	/ SEP	१८ अध्य	30 SEPT	17 OCF	/ Mov	15NOV	I DEC	S DEC	30 DEC
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74z	74.6	743	73.7	735	730	73.4	73.5	745	74.9	765	765	77.2	77.9	78.0	785	80D	79.5	Bo.1	804	81.0	<i>8</i> 13:	22.0	82.7	824
														81.0		-	83.2	<i>8</i> 3.8	<i>8</i> 39	84.6	84.9	85.79	86.4	867
				43.8	449	45.1	46,0	47.6	47.4	464	459	443	475	47.7	47.6	47.4	48.1	475	485	480	48.0	485	490	48.8
71.0	7/.3	71.0	70.2	69.8	69.4	70.2	708	725	733	750	755	765	77.1	77.3	77.8	7 <i>8.</i> 3	78.6	79.4	79.B	80.Z	806	81.4	82.3	82.9
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				43.0	446	45.7	47.1	47.8	47.3	4.4	45.6	47.4	485	484	48.0	476	476	47.9	49.4	489	49.1	543	-	_
865	<i>6</i> 6.7	86,7	855	85.3	84B	85.4	86.2	87.8	886	90.1	905	91.1	915	91.6	91.9	925	928	933	934	938	938	944	95.1	954
87.7	87.7	<i>8</i> 7.3	<i>8</i> 6.8	86.4	85.7	865	28.6	89.1	89.7	9/./	91.2	91.9	92. <i>1</i>	92.4	924	92.9	9 3 2	937	93.9	99.2	942	94.9	9517	94.7
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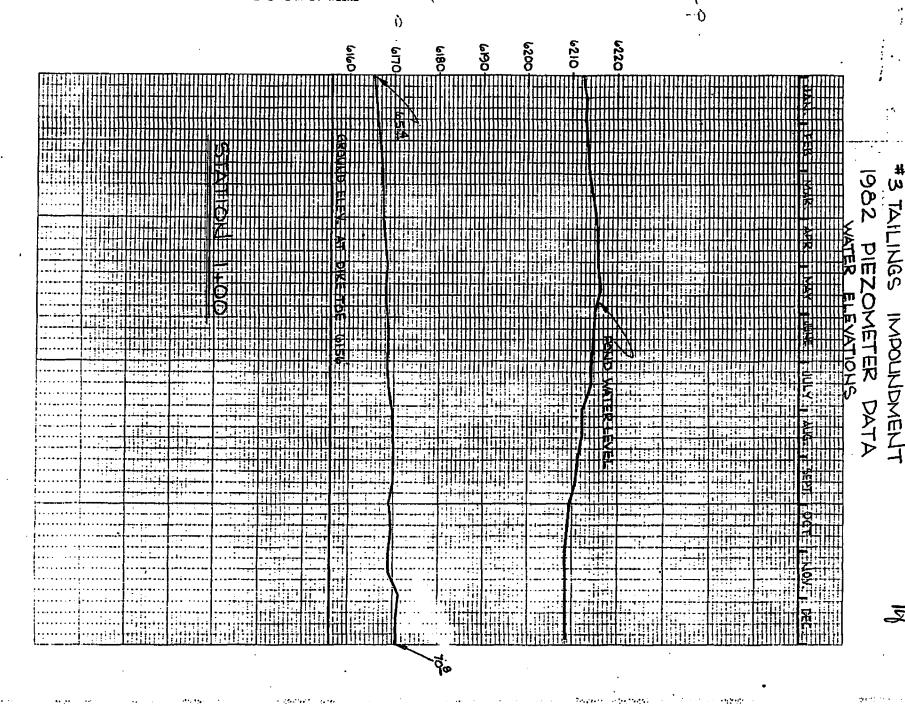
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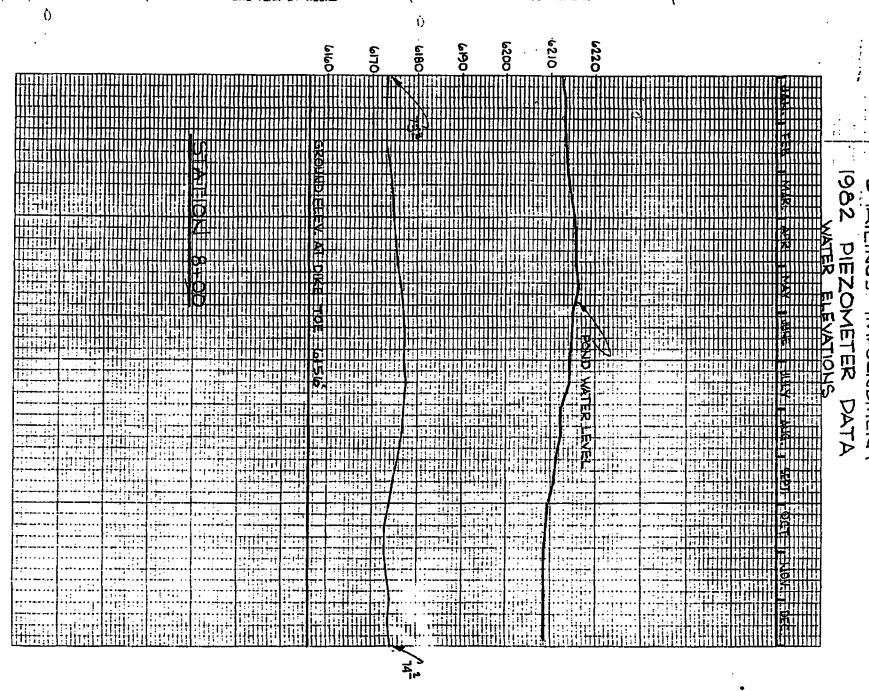
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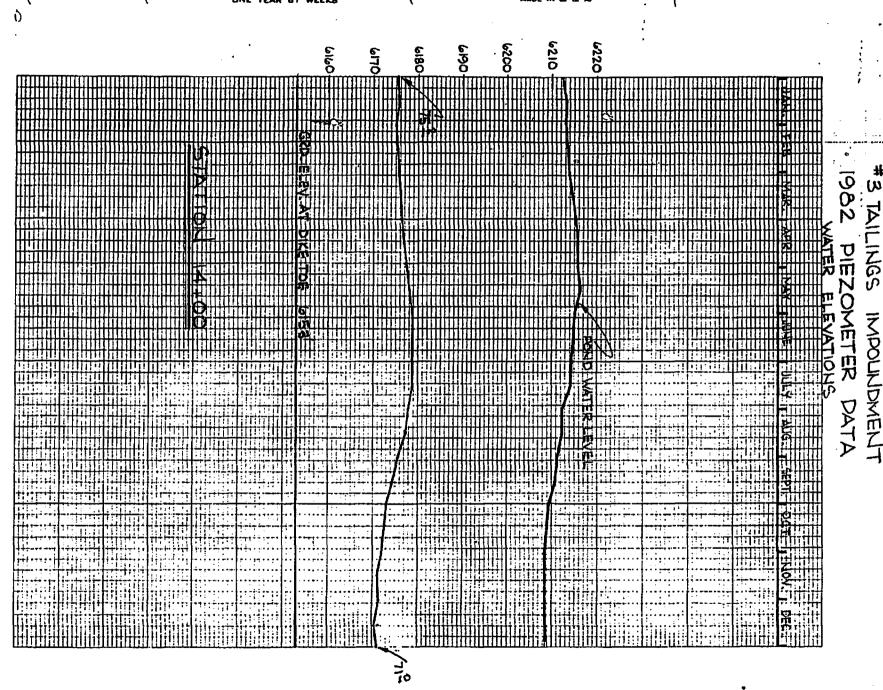
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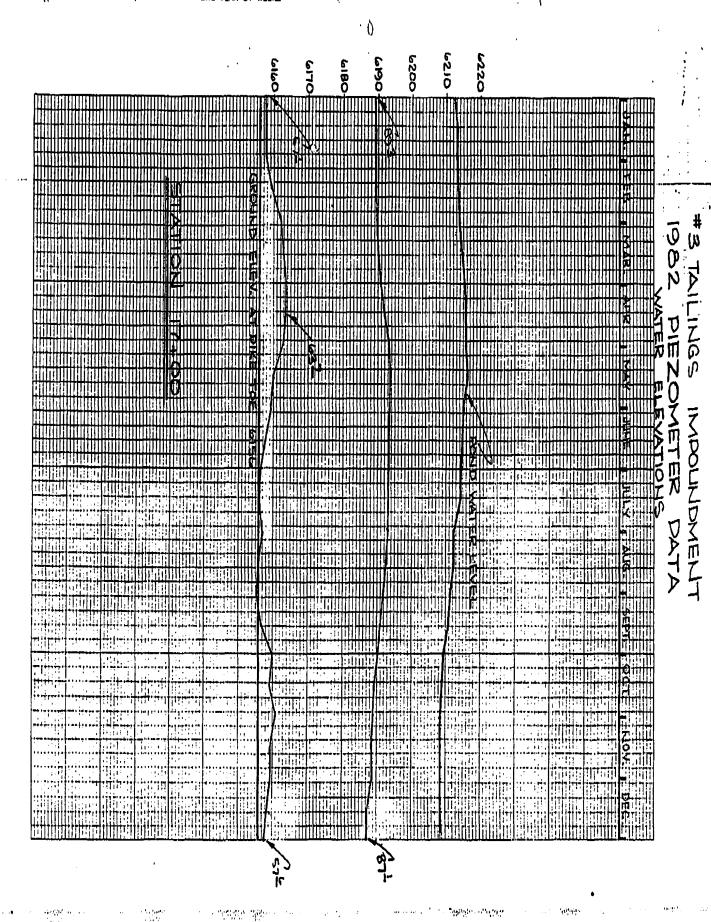
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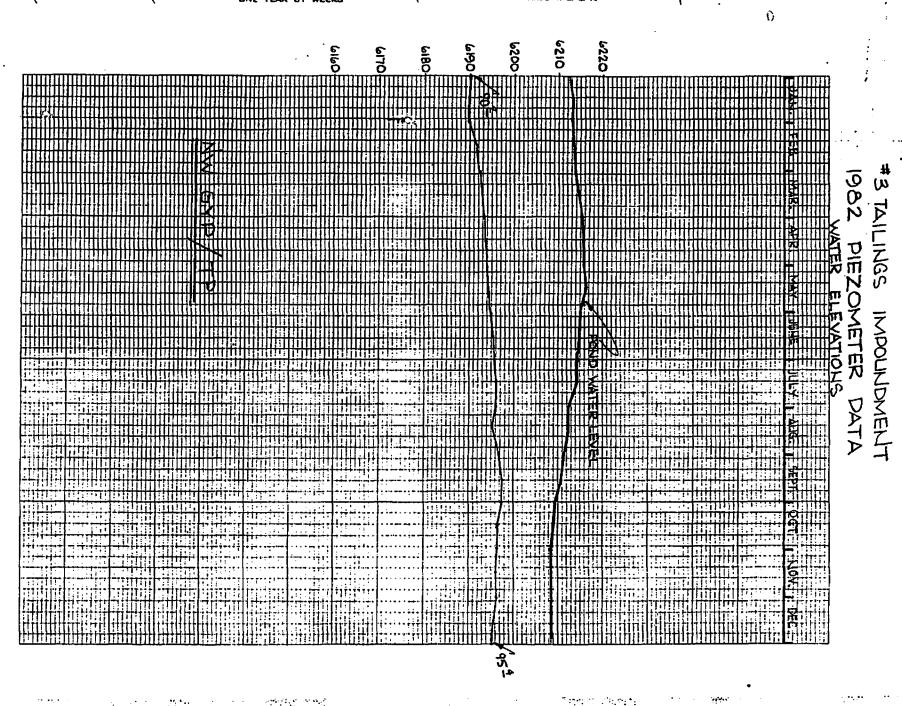
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WATER ELEVATIONS

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800 crest	73.3	732	73.2	75.4	74.1	74.0	74.9	75.3	75.1	76.5	77,1	17.2	773	77.5	77.0	76.7	75.9	74-8	73.9	73.0	72.8	73.5	74.2	79.1	74.7		٠,
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36+00 (2551	70.3	71.52	EEN.EW	72.2	72.1	72.5	73.1	78.A	73.3	14,5	74.9	`14. ₀	75.0	75.A	76.1	74.6	73.B	73.4	72.7	71.5	70.7	70.8	71.4	uNDE	ir show		
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AND SHALL NOT BE REPRODUCED, COPIED, LENT OR CTHERWISE DISPOSED OF DIRECTLY OR INDIRECTLY, MOR USED FOR ANY PURPOSE OTHER THAN THAT FOR WHICH IT IS PREDITICALLY						<u> </u>	╀	APPR BY			SCALE:	Dwg. No.	IREV.	
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TAILINGS IMPOUNDMENT NO. 4

FOR CONDA PARTNERSHIP

PINNACLE ENGINEERING COMPANY, INC.
HAMILTON, MONTANA

REPORT ON

TAILINGS IMPOUNDMENT NO. 4

FOR CONDA PARTNERSHIP



Ву

PINNACLE ENGINEERING COMPANY, INC.
Hamilton, Montana

January 1985

Project No. PEC-84-0386

TELEPHONE: (406) 363-3502

716 SOUTH FIRST TOWNE & COUNTRY PLAZA HAMILTON, MONTANA 59840

March 21, 1985

Mr. Robert J. Hitt, P.E. Engineering Supervisor Beker Industries Corporation Box 37 Conda. Idaho 83230

Reference: Tailings Impoundment No. 4
Conda Partnership Operations

Dear Mr. Hitt:

This letter is to transmit and summarize our final report on the Tailings Impoundment No. 4 Project for the Conda Partnership. Our work which was authorized by Beker Industries' Purchase Order No. 57999 dated July 20, 1984, consisted of:

- A. Resident engineering services during the initial stage of construction and
- B. Stability analysis of the embankments.

During July of 1984, Northern Engineering and Testing, Inc., under our direction, obtained soil samples for laboratory testing to determine the design strength parameters of the foundation soils and initial stage embankment construction materials. At that particular time gypsum was proposed for subsequent construction stages. As such, the detailed information about gypsum as a construction material obtained during the design and construction of Tailings Impoundment No. 3 was to be used in evaluating the stability of subsequent stages.

Based upon preliminary laboratory test results and a detailed review of Harza Engineering Company's report on No. 3 Impoundment, the initial embankment configuration was established to construct a one year - 70 acre starter impoundment. A resident engineer was onsite during a major portion of the starter impoundment construction between August 18 and October 6, 1984. These embankments were constructed to a crest elevation of 6175 feet using onsite native materials.

Mr. Robert Hitt March 21, 1985

The initial project program was to enlarge the starter impoundment to the west, leaving room for a future gypsum pond on the far west portion of the site. This enlargement was to be built in a similiar manner as the starter impoundment with native soils used for embankment construction to a crest elevation of 6179. Gypsum was to be used for subsequent construction to raise the embankment height on No. 4 Impoundment to a crest of 6235. Our stability analysis for this crest height was based upon this initial project plan and our report is addressed primarily to that end.

However, prior to finalizing this report, Beker and the Conda Partnership elected to revise the project plan to utilize the entire north site for tailings disposal. Further, it was determined that if the material on the northeastern adjacent Torgesen property can be obtained, the embankments on this total site impoundment can be constructed to a crest of 6191 using native materials and could possibly be constructed to the 6235 elevation if material can be used from the Partnership property east of the Monsanto Haul Road, near the Plant.

As such, additional stability analyses were performed for the total impoundment embankments to a crest elevation of 6183 using the native material properties determined by Northern Engineering. Based upon the Partnership's projections, a total site impoundment with a crest elevation of 6183 will have storage capacity for approximately 6 years production.

Beyond this elevation further investigation of the embankment stability will be required. At that time the strength parameters of the remaining Torgesen site and the east Partnership site soils must be determined for final design of Tailings Impoundment No. 4.

We sincerely appreciate the opportunity of working with Beker Industries on this project. Please contact us if you should have any questions or if we can be of assistance in your submittal to the State of Idaho.

Sincerely,

PINNACLE ENGINEERING COMPANY, INC.

James B. Carpita, P.E.

President

JBC/rda

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I INTRODUCTION

A. PROJECT DESCRIPTION

Beker Industries Corporation's Conda, Idaho plant manufactures Phosphate Fertilizer Products. One of the by-products of the manufacturing process is phosphate ore slimes. These slimes are very fine particles of soils washed from the ore and are in the silt and clay size range. The slimes are transported in a water solution to settling impoundments for disposal. The transport water is decanted off and returned to the wash plant for re-use.

Beker and previous owners have constructed three such slime settling ponds referred to as Tailings Impoundments No. 1, No. 2 and No. 3.

B. PURPOSE

The capacity of the existing tailings impoundments has been increased to the economical and physical limits by various methods; raising embankments, dredging, etc.. As such, additional impoundment capacity is required if the plant is to continue to operate.

In 1981, two locations for possible Tailings Impoundment No. 4 were investigated by Beker personnel. The economic as well as physical evaluation of a site to the south of the plant and of a site contiguous to the north of Tailings Impoundments No. 1 and No. 2 resulted in the selection of the North site.

C. SCOPE OF STUDY

In order to provide Beker with the necessary slimes storage volume, the following engineering services were provided:

1. Northern Engineering and Testing, Inc. conducted field investigations of the area as part of Beker's 1981 evaluation of the two proposed sites. However, no laboratory testing of the strength parameters for site soils was conducted. As such, in July of 1984

additional samples were taken from test pits adjacent to selected 1981 boring locations for laboratory testing.

- 2. A review of previous engineering reports and historical data for Beker's tailings impoundments was conducted in order to assist Beker personnel in the planning of Tailings Impoundment No. 4.
- 3. Resident Engineer services were provided during the construction of the initial phase of the embankments.
- 4. Embankment configuration and stability were evaluated using data obtained from the review of previous reports and the 1984 testing program.
- 5. Alternative construction methods were evaluated; upstream impervious liner requirements, chimney drains, reinforced earth type construction, downstream drainage requirements, and wick drains for the foundation materials.

II MATERIAL PROPERTIES

A. FOUNDATION MATERIALS

A geological reconnaissance and an extensive drilling program were conducted in 1981 of the north site selected for Tailings Impoundment No. 4. Subsequently, additional samples were taken in July of 1984 on which laboratory testing was conducted to determine the strength parameters of the underlying foundation soils.

1. Exploration

In February of 1981, Northern Testing was retained by Beker to perform a geological reconnaissance of the proposed site. This reconnaissance revealed that a vast majority of the site is underlain with Quaternary olivine basalt. This basalt is covered with from 12 to 25 feet of lakedeposited silts and clays. Northern's report, contained in Appendix A., recommended a more detailed study of the site be conducted.

As such, a drilling program was performed in late August and September of 1981 and consisted of eleven primary, nine secondary, and six probe hole borings ranging in depth from 11 feet to 131 feet. In addition, 18 test pits were dug. Boring logs were kept of all holes. Although samples were obtained during this drilling program, no laboratory tests were conducted except for visual classification and inplace moisture content. The location of the borings and test pits are shown on the north site topography map (Dwg. No. 09-1-42) with the logs contained in Appendix B.

Later in July of 1984, after the determination was made by Beker to purchase the north site for Tailings Impoundment No. 4, undisturbed shelby tube and grab bag samples were taken from test pits dug with a backhoe alongside of selected 1981 boring locations. The shelby tubes were driven with a jack into the soft subsurface soil stratas. A total of ten locations were sampled.

The next has te was purchased in after feb 1984 not after July The drilling and sampling exploration program confirmed the geological reconnaissance. However, the deep hole borings indicated the basalt underlying the area appears to terminate along the eastern portion of the impoundment site, see Exhibit 1. The east half of the north embankment is underlain with layers of fine silty sands and sandy silts with lenses of clayey silts to a depth of 43 feet. Sandy Gravels were then encountered to the bottom of the boring (DH-P2) at 55 feet. A high groundwater table was encountered.

Boring along the east embankment revealed layers of varying thicknesses of clayey silts and sands, silty sands with some cementation, and silty gravels to a depth of 75 feet. The remaining portion of the impoundment is underlain with silty sands and sandy silts with some clay lenses over the basalt in varying depth from 8 to 25 feet, similiar to the foundation materials encountered under existing embankments of Tailings Impoundment No. 3. (Refer to Appendix C of Harza Engineering Company's September 1978 "Report on No. 3 Tailings Impoundment Expansion" 1).)

2. Laboratory Testing

The shelby tube and grab bag samples collected in July, 1984 were taken to Northern Engineering and Testing, Inc.'s laboratories to determine the strength parameters and engineering properties of the soils, including triaxial shear and direct shear strengths, Atterberg limits, and consolidation rate, results of which are included in Appendix C. From the consolidated undrained triaxial tests, the friction angle, \emptyset , varied between \emptyset ' = 28° and \emptyset ' = 35° with cohesion of the materials at \mathbb{C} ' = 0, as determined on Exhibits 2, 3, and 4 for effective stresses.

B. EMBANKMENT MATERIALS

As with the existing tailings impoundments, the initial and second phases of construction for Tailings Impoundment No. 4 embankments will consist of using onsite native materials from the impoundment floor as well as from the hill wash-colluvium deposits along the eastern property line. Subsequent stages will be built with another by-product of the manufacturing processess, gypsum, or of native materials, if sufficient quantities of adequate strength soils can be economically found adjacent to the site.

1. Native Soils

In addition to testing the foundation materials obtained in July, 1984, the materials proposed for use in the initial phase of embankment construction were tested in Northern's laboratory. Samples from the potential borrow sites were tested for moisture-density relationships, sieve analysis, Atterburg limits, direct shear strengths, and permeability. The site sand/sandy silts were to be obtained from the impoundment floor, while silty gravels and sandstone/siltstones were to be borrowed from the periphery of the property.

The silty sand friction angle, Ø' determined by direct shear tests on remolded samples varied between 32° and 33° with a cohesion of 600 and 400 pounds per square foot, respectively. This is less than the 35° and 500 pounds per square foot found by Dames and Moore in the evaluation of the existing embankments on Tailings Impoundments No. 1 and No. 2.²⁾

2. Gypsum

The engineering properties of gypsum were well defined by Harza Engineering in their 1978 report of the design of Tailings Impoundment No. 3. Harza's design was based upon laboratory testing conducted in their facility as well as Northern Testing Laboratories. The results of Northern's tests are included in

III CONSTRUCTION STAGES

In order to keep the slimes disposal cost in line with production costs and to balance gypsum product with embankment construction requirements, Beker proposes to construct Tailings Impoundment No. 4 in stages. The downstream method of embankment expansion will be used as the slimes are incapable of supporting the embankment weights.

A. INITIAL PHASE

The initial phase consisted of constructing the "starter" embankments from native soils during the late summer and fall of The crest elevation of these starter embankments is 6175 feet with natural grade between 6150 feet and 6162 feet. Based upon Beker's as built survey, an average of 3 feet of silty sands/ sandy silts were excavated from the southern portion of the impoundment, thus the starter embankments varied between 13 and 28 feet. The side slopes were constructed at 1.5 horizontal to 1.0 vertical with a crest width of 30 feet, see Drawing No. 09-1-40. The native materials were excavated from the impoundment floor, the knoll at the northeast corner of the impoundment and along the east property line using scrappers. These various materials were blended on the fill depending upon the moisture contents and compacted using self-propelled sheepsfoots pulling additional rollers and pheumatic compaction equipment. Moisture-Density relations were determined in the field for the blended materials and compaction tests run to control compaction to 95% of the maximum dry densities determined by ASTM D-698, methods A & D. Efforts were made to control the compaction moisture to \pm 3% of optimum. A daily log of construction is found in Appendix E.

According to Beker's estimates, this initial phase has an estimated storage volume of 1155 acre-feet. At the filling rate of 1.0 acre-feet per 1000 tons of ore, established by Beker for the existing tailings impoundments, the initial phase would allow 1.1 years storage to the pool elevation of 6170 feet at projected plant production rates.

B. EMBANKMENT MATERIALS

As with the existing tailings impoundments, the initial and second phases of construction for Tailings Impoundment No. 4 embankments will consist of using onsite native materials from the impoundment floor as well as from the hill wash-colluvium deposits along the eastern property line. Subsequent stages will be built with another by-product of the manufacturing processess, gypsum, or of native materials, if sufficient quantities of adequate strength soils can be economically found adjacent to the site.

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Appendix D and were used in the stability analysis of No. 4 embankments where gypsum is proposed for subsequent stages of construction. The effective stress parameters determined from Northern's report for gypsum compacted to 98% of Standard Proctor is $\emptyset' = 40^{\circ}$ with C' = 0 from triaxial shear tests.

B. SECOND PHASE

Development of the entire property limits for the second construction phase is shown on Drawing Number 09-1-40. The use of native material from Conda Partnership land is sufficient to build an embankment to elevation 6179. With material from the Torgesen property, the embankments can be raised to elevation 6191. However, prior to increasing the embankment height above 6183, further stability analysis will be required to verify the cross sectional geometry and integrated embankment drainage criteria meets all of the stability requirements for native soils.

In addition to increasing the embankment height from the initial crest elevation of 6175, it is proposed to enlarge the impoundment area to the west as shown on Drawing Number 09-1-40. During 1985, the second phase embankments would be constructed in the same manner as the initial phase using native materials to build the embankments to a crest elevation of 6179 feet. The second phase would increase the storage capacity by 3775 acre-feet to a total of 4930 acre-feet. The combined life of the initial phase plus the second phase is estimated at 4.9 years based upon projected plant production rates.

C. SUBSEQUENT STAGES

Similiar to Tailings Impoundment No. 3, No. 4 Impoundment will be expanded beyond the Second Phase by downstream construction using gypsum as the embankment material. The gypsum will be borrowed from gypsum waste piles and compacted with mechanical equipment to assure embankment stability. The rate of embankment construction necessary to provide the required slimes impoundment volume is depicted in Exhibit 5.

Based upon one year intervals, the ultimate height of the embankments will be constructed in 12 stages after Phase B. The total volume of compacted inplace gypsum in the embankments is projected at 5.0 cubic yards or an average construction of 417,000 cubic yards per year.

IV EMBANKMENT STABILITY

A. GENERAL

In evaluating the stability of the embankments, representative shear strength parameters to be used in the analysis were obtained from previous test results for the gypsum 1) and from laboratory tests of the native foundation soils at the site. Trial crosssectional configurations with various phreatic surfaces imposed were evaluated for the various embankments. The final embankment configurations addressed in this report are shown on Drawing No. 09-1-41. The criteria for acceptance is based upon the State of Idaho's Department of Water Resources' "Rules and Regulations for Mine Tailings Impoundment Structures", October 1980 3). Rule 7.1.1.c requires "safety factors for the embankment shall be at least 1.5 for static loads and a minimum of 1.0 for the static plus the appropriate earthquake load." Rapid drawdown was not considered as a reasonable posibility due to the operational characteristics of slime tailings impoundments with transport water decanted to maintain water balances in the production plant. The various trial configurations were evaluated against these criteria using a computer program.

1. STABL

STABL is a copyrighted computer program by Design Professionals Management Systems. The program was originally written by Ronald A. Siegel at Purdue University for the general solution of slope stability problems using a two dimensional limiting equilibrium method. The version employed by STABL is an adaptation of the Modified Bishop method of slices. The adaptation allows the analysis of the trial failure surfaces including those of circular shape. Using random techniques for general potential failure surface allows subsequent determination of the more critical surfaces and their corresponding factors of safety. The technique used in evaluating Tailings

Impoundment No. 4 embankments generated 100 trial circular surfaces for each computer run. The ten (10) most critical surfaces with corresponding factors of safety are accumulated and ordered-most critical first. In evaluating the embankments the soils parameters for various phreatic surfaces are imput. The most critical surface for the design phreatic surface is shown on the stability analyses Exhibits 6 thru 14.

B. PHREATIC SURFACE

The stability of the embankment has a direct relationship to the configuration of the phreatic surface within the embankment as well as the founding soils. Therefore, in analyzing the stability of the embankment it is important to assign a realistic location to the design phreatic surface. Since Harza's evaluation of the stability of Tailings Impoundment No. 3 using data from stages I and II of construction, the embankments on that impoundment have been raised within 12 feet of the maximum design height. As such piezometer data from this impoundment was available for use in assigning potential phreatic surfaces, based upon similiar conditions, to the No. 4 Impoundment embankments. The limiting phreatic surfaces based upon the No. 3 Impoundment correlations are shown on the stability analyses exhibits.

However, it should be noted that due to the variations in the foundation compositions between the No. 3 and the No. 4 sites, the critical phreatic surfaces are lower and as such downstream drains may be required to maintain the lower pore pressures within the embankments.

C. FINAL STAGE

Due to the physical constraints of the site (existing No. 1 and No. 2 Tailings Impoundments to the south, deep foundation soils on the north and east, high groundwater table, irrigation ditch requirements, etc.) the configuration of the embankment changes around the impoundment. Exhibits 6 thru 10 show the results of

the stability analyses for the embankment configurations and critical phreatic surfaces. The ultimate design height corresponding to a crest elevation of 6235 feet is 85 feet with a maximum pool elevation of 6232 feet.

1. STEADY SEEPAGE STATE

Each section of the embankment was analysized at its ultimate design height at a steady seepage for the fully developed phreatic surface indicated on the respective exhibits. The lowest factor of safety as shown on the exhibit for each section ranges between 1.5 and 1.8.

2. EARTHQUAKE LOADING

The impoundment is located east of Range 22 East, Boise Meridian. Therefore, Section 5.2.1g of the Rules and Regulations requires an earthquake analysis of the embankments based upon a Seismic Zone 3 loading. The STABL computer program used evaluates the seismic stability based upon psuedo-static earthquake loadings by applying a horizontal loading coefficient of 0.100 in the direction of failure.

Harza Engineering's report 1) on the Stability of No. 3 Impoundment includes a detailed section on gypsum during earthquake type loading conditions. The properties used in the analysis of Tailings Impoundment No. 4 were adapted from that report. Exhibits 8 and 9 indicate the results of applying an equivalent static load to cross-sections C and D which are the most critical sections evaluated. The resulting factors of safety are 1.108 and 1.107 respectively as compared to the minimum requirement of 1.0.

D. SECOND PHASE

As noted, onsite native materials of sufficient volume are available to construct the entire impoundment embankments to a crest

elevation of 6179. To raise the embankments to a crest elevation of 6183 as noted in Exhibits 11, 12 and 13, an additional 262,000 cubic yards of native materials will have to be borrowed from the portion of the northeast knoll located on the Torgesen Property.

Phreatic surface 1 indicated on the Second Phase Stability Exhibits is a projection of the piezometric surface from No. 3 Tailings Impoundment final stage. As previously noted, the phreatic surface in No. 3 Impoundment was actually even lower during the inital stages of construction. Therefore, for this second phase stability analysis with crest elevation at 6183, the assumed phreatic is on the conservative side.

If however, after constructing the embankments to 6179 it is found that the phreatic surface does tend to be higher within the embankments, downstream drains should be installed to maintain the piezometric surface at or below 3 level.

E. INTERMEDIATE STAGE

Exhibit 14 indicates the results of the steady seepage state analysis of an intermediate stage of construction. The analysis was performed on Embankment Section C which has a deep soil foundation at the point when a fully developed phreatic surface is established at a pool elevation of 6200 feet and a crest elevation of 6205 feet. As indicated, downstream drains will apparently be required to lower the phreatic surface to result in a factor of safety of 1.5.

F. DOWNSTREAM DRAINAGE SYSTEMS

As can be seen from the stability analyses exhibits, downstream drainage networks will be necessary on cross-sections B, C, D, and E after the pool elevation forces the rise in the phreatic surface similiar to that experienced in Tailings Impoundment No. 3. This drainage system would be installed as indicated in those exhibits in accordance with the attached construction drawings.

In addition to downstream toe drains, Embankment Sections D & E will have an upstream liner to restrict seepage above the second phase of construction, crest elevation of 6183.

V SUMMARY

The merits of using compacted gypsum as an embankment construction material was well documented in Harza's report on Tailings Impoundment No. 3. In addition, the actual onsite use by Beker has reinforced Harza's finding. As such, the basis for evaluating the stability of No. 4 Impoundment is the detailed work done by Harza and the experience at this site.

A. EMBANKMENT DETAILS

İ.

The stability of embankments is dependent upon the foundation conditions, materials used to construct the embankment, pore pressures/phreatic surfaces within the embankment, seepage control and drainage. In addition, long term protection of the embankment slopes is required to assure the configuration of the embankment remains consistant with those analyzed.

1. Configuration

The final configuration of the embankments as determined by the site restraints and the above note parameters are shown on Drawing No. 09-1-41. The upstream slope varies between $1\frac{1}{2}$ feet horizontal to 1 foot vertical $(1\frac{1}{2}$ H: 1 V) and 2 H: 1 V, while the downstream slope varies between 2 H: 1 V and 3 H: 1 V. These results are comparable to those determined in the analysis of No. 3 Impoundment for similiar foundation conditions. (i.e., west and south embankments.) However, the downstream slopes for the east and north embankments had to be flattened in order to distribute the embankment loading over a wider area where the weak foundation materials have a greater thickness.

The data from piezometers installed in the existing No. 3 Impoundment embankments also had a direct effect on the configuration in that this data was used to determine the piezometric surface within the embankments of Tailings Impoundment No. 4. As shown on the

stability analyses exhibits, the configuration is dependment upon the placement of drains in the downstream area to lower the phreatic surface within the factor of safety established by the Department of Water Resources.

2. Drainage

As noted, a drainage system must be installed to increase the calculated factor of safety to the minimum requirements. The use of drains was investigated by Harza on No. 3 Impoundment based upon data from the first two stages of construction. Although their initial findings were that drains were not needed for stage III, drains might be necessary as the embankment height increased.

Beker has reported the need for providing drainage for the downstream toe on a portion of the north embankment of Tailings Impoundment No. 3. As such the need for future drainage of the downstream areas on No. 4 Impoundment, in order to keep a lower piezometric reading within the embankments, is considered essential to the stability of the impoundment. The placement of these drainage networks is shown on the Construction Drawings. A geocell mattress type of drainage system is recommended which not only provides the required drainage, but increases the foundation stability through its rigidity, high friction values, and greater tensile strengths.

Seepage Liner

Experience with Tailings Impoundment No. 3 has indicated that the slimes provide adequate seepage control to prevent excessive water losses through the embankments or impoundment floor. However, due to the weak foundation soils and associated high groundwater table under the north embankment, the phreatic surface

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must be maintained at or near the crest of the initial starter embankment at its highest point. An impervious liner placed on the upstream slope of each subsequent construction stage coupled with the geocell mattress drain would result in the phreatic surface being maintained as indicated in Exhibits 9 and 10. A spunbounded polyethylene fabric coated with an EVA film with a total thickness of 15.5 mils, similiar to Du Pont's TYPAR Style No. 3358, should provide the necessary seepage restraints for the north embankment.

As an alternative to the upstream liner, the use of chimney drains in the embankment, wick drains in the underlying foundation, and downstream toe reinforcement with a high strength grid structure could result in steeper slopes and potential cost savings.

4. Slope Protection

The second secon

The upstream slopes should be protected from wave action and associated erosion. Rip—rap using plant reject rock, pitrun slag, or other durable materials has proven satisfactory for upstream slope protection on No. 3 Impoundment. As such, it's continued use on No. 4 Impoundment is recommended.

The downstream surfaces of the embankment should be dampened then "walk-in" with a crawler type dozer to cement/compact the surfaces for an approximate six inch thickness. This also has shown to be an acceptable method from use on the existing embankments.

5. Pool Elevation

The maximum pool elevation should be kept at an elevation of 5 feet below the existing crest elevation of the completed embankment until the subsequent stage is totally completed including upstream protection and

liner installation. The free water depth in the impoundment should be kept to the minimum required for proper settlement of the slime before decanting off in order to decrease seepage and maintain embankment stability.

6. Observation Wells

Piezometers shall be installed upon completion of each stage of construction as detailed on Drawing No. 09-1-41 B. Readings shall be taken at intervals agreeable to the Department of Water Resources. Monthly intervals should be satisfactory except in periods when the levels are increasing at which times weekly readings are recommended.

7. Construction Procedures

In order to maintain the factors of safety determined by the stability analyses, the following construction procedures should be followed:

a. GENERAL CONDITIONS

In establishing the lines and grades necessary to construct the embankments to the height and width specified, it will be necessary to provide for shrinkage during compaction.

b. SITE PREPARATION

- 1) Stripping Stripping will be conducted in fill areas as required to remove undesirable and highly organic material.
- 2) <u>Fill Areas</u> Prior to placing fill in any area, grading is to be performed as required to provide for drainage. Provisions shall be made to intercept and divert all surface water possible from fill areas. When the fill areas have been prepared as specified

above, the base shall be compacted by methods specified for compaction of fill.

c. PLACEMENT AND PREPARATION OF FILL

- 1) Source and Character Fill material shall be obtained from native sources and blended as directed by the Engineer for the second phase of construction. Subsequent stages will be constructed using gypsum borrowed from areas as directed by the Engineer upon approval of Beker's Engineering Department. Placement of fill on frozen ground or fill which is frozen will not be permitted.
- 2) Sequence of Operations Filling shall begin in the lowest section of the area. Fill will be spread in layers as hereinafter specified. Each layer shall extend the entire length and width of the embankment. Existing dikes are to be widened and included in the new embankments, and as such, steps shall be cut into the existing slopes at each layer of new fill and crests of existing dikes shall be plowed deep prior to placement of new fill on top. New and existing fill shall be tied together by fully compacting along with each layer. The surface of each layer shall be approximately horizontal, but will be constructed with sufficient longitudinal and traverse slope to provide for runoff of surface water from every point. Filling will be conducted so that no obstruction to drainage from other sections of the fill areas is created at any time.
- 3) <u>Layer Construction</u> Fill shall be spread in approximately horizontal layers of 6 inches maximum thickness when in the loose uncompacted

condition, shall be uniform in cross section, and shall be thoroughly compacted as herein after specified before the next layer is started:

- 4) <u>Condition</u> Each layer of fill shall be inspected prior to compaction. All visible debris shall be removed. Stones larger than 6 inches in diameter shall be removed. The water content of each layer shall be determined to be suitable for compaction or shall be brought to a suitable condition by measures hereinafter described. Materials incorporated in the fill which are not in satisfactory condition shall be subject to rejection and removal.
- 5) <u>Protection</u> The working surfaces shall be regularly sealed at the close of each work day and during the day as possible prior to rainfall.

d. COMPACTION

- 1) Degree of Compaction The fill material shall be compacted so that the unit dry weight of the compacted material is equal to or greater than 98 percent for gypsum and 95% for native soils of the maximum unit dry weight of material compacted in the laboratory under standard proctor compaction specification as determined by ASTM D-698-64T.
- 2) <u>Procedure</u> Special care shall be taken to assure that the existing dikes are tied into new embankments by fully compacting the plowed and stepped areas with new fill. Each successive pass shall overlap the preceeding adjacent pass by 10 percent.

3) Moisture Content - Fill will be compacted only when the water content is within the limits of 2 percent less to 3 percent greater than the optimum as determined by the standard proctor specifications as determined by ASTM D-698-64T.

The water content of the fill material may be reduced by discing, harrowing, tilling, or other procedure appropriate for obtaining or promoting aeration as necessary, including changing the blend of native materials used during the second phase of construction. The water content may be increased, if necessary, by addition of fresh water only on the fill material after it is placed. The added water must be evenly distributed through the fill material prior to compaction.

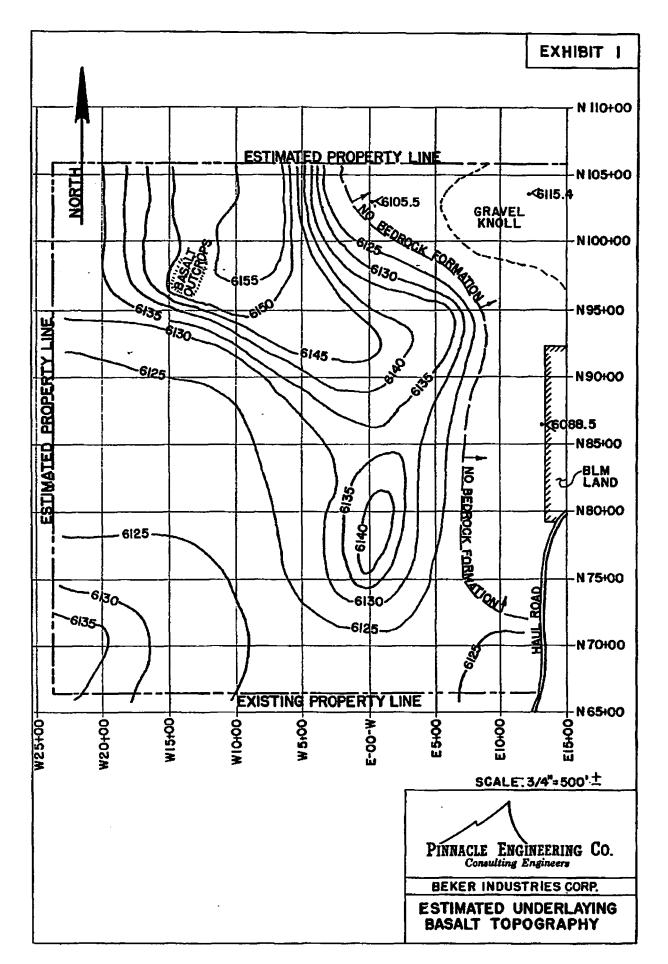
e. TESTING

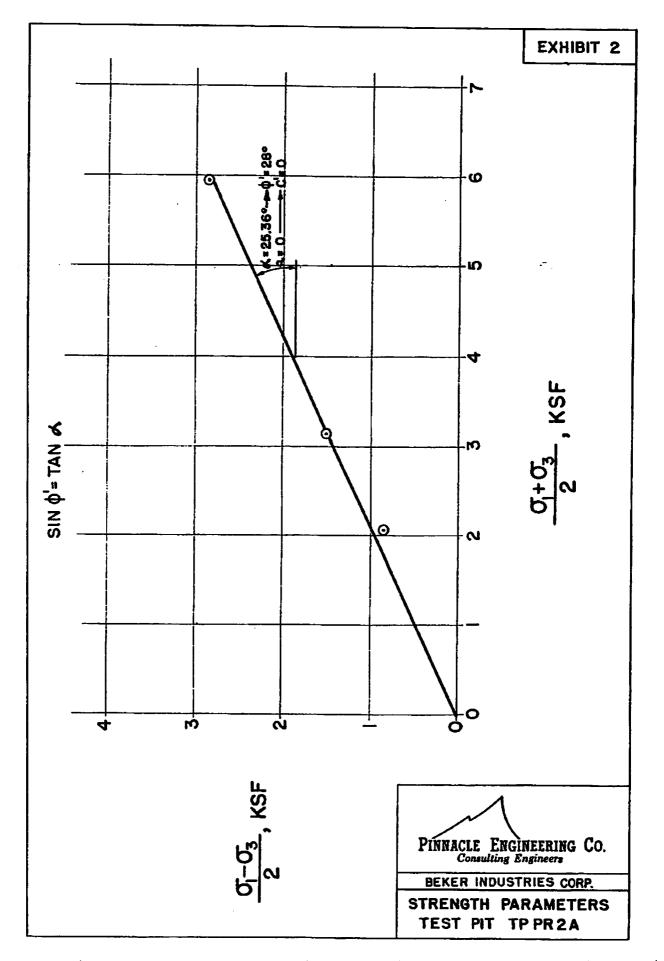
The acceptability of compaction should be established by tests conducted by a soils testing laboration. The unit weight of the compacted materials will be established by in-place density tests conducted by the sand-cone method, ASTM D-1556-64 (or last approved revision), nuclear densometer equipment, and/or other tests deemed necessary to assure a satisfactory job.

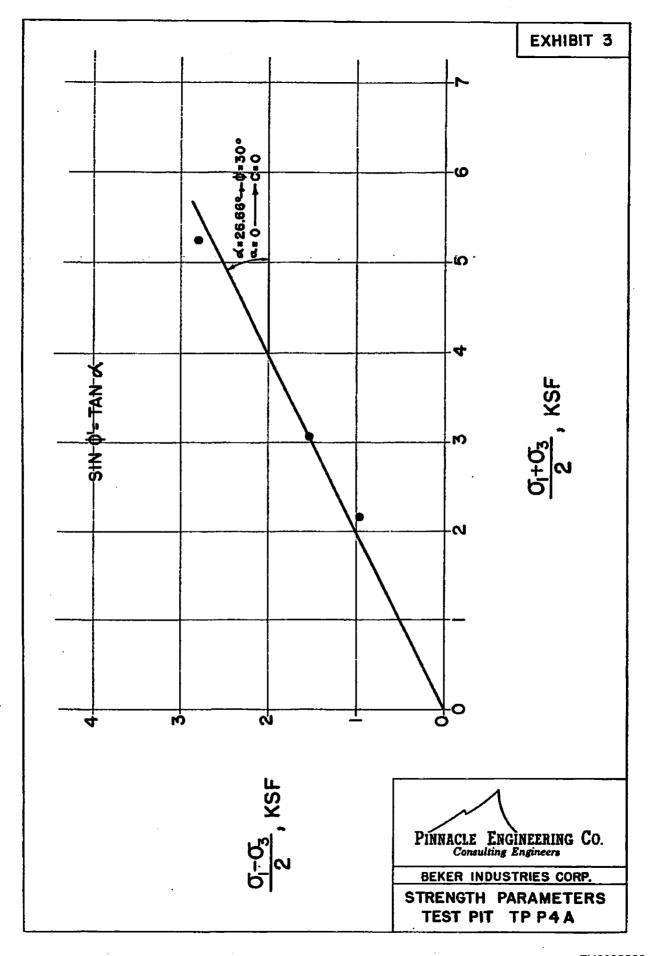
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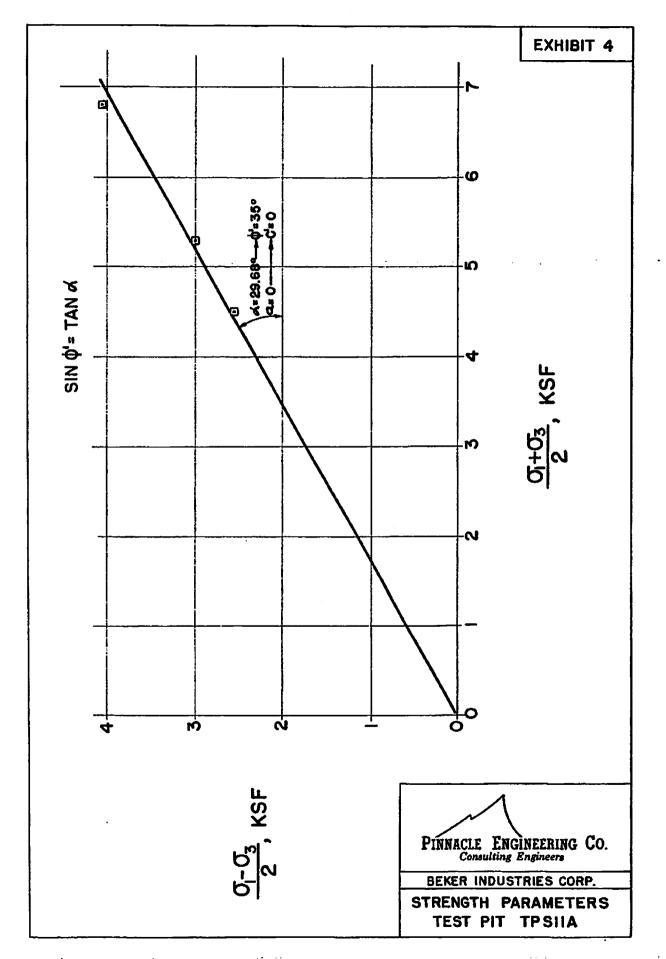
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- 3) State of Idaho-Department of Water Resources, Rules and Regulations for Mine Tailings Impoundment Structures, October 1980.
- 4) Design Professional Management Systems "STABL", Computer Analysis of General Slope Stability Problems, 1983, Kirkland, Washington.

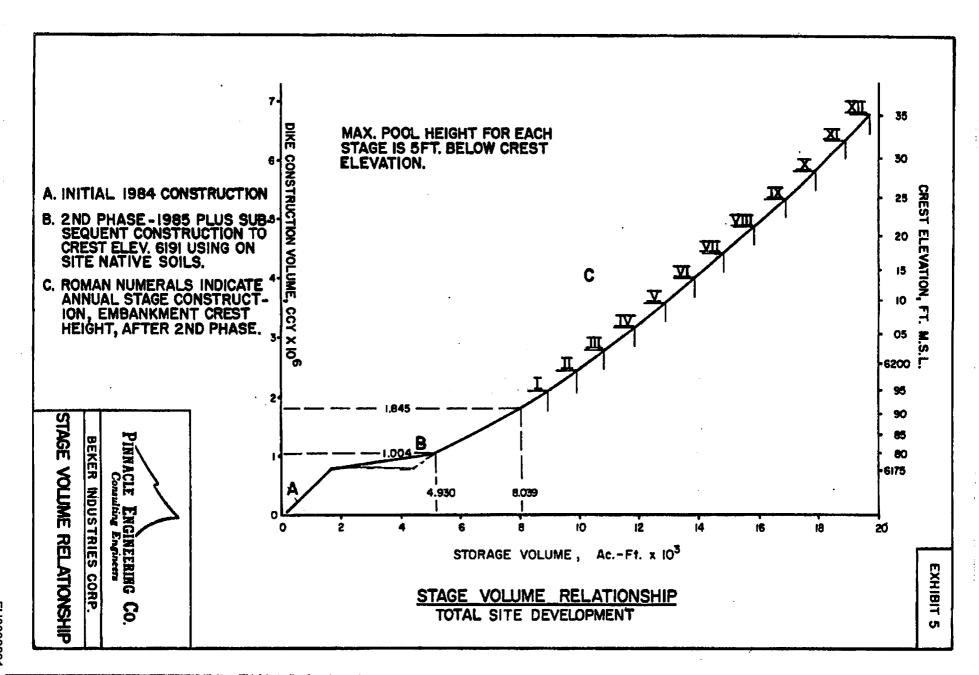
EXHIBITS

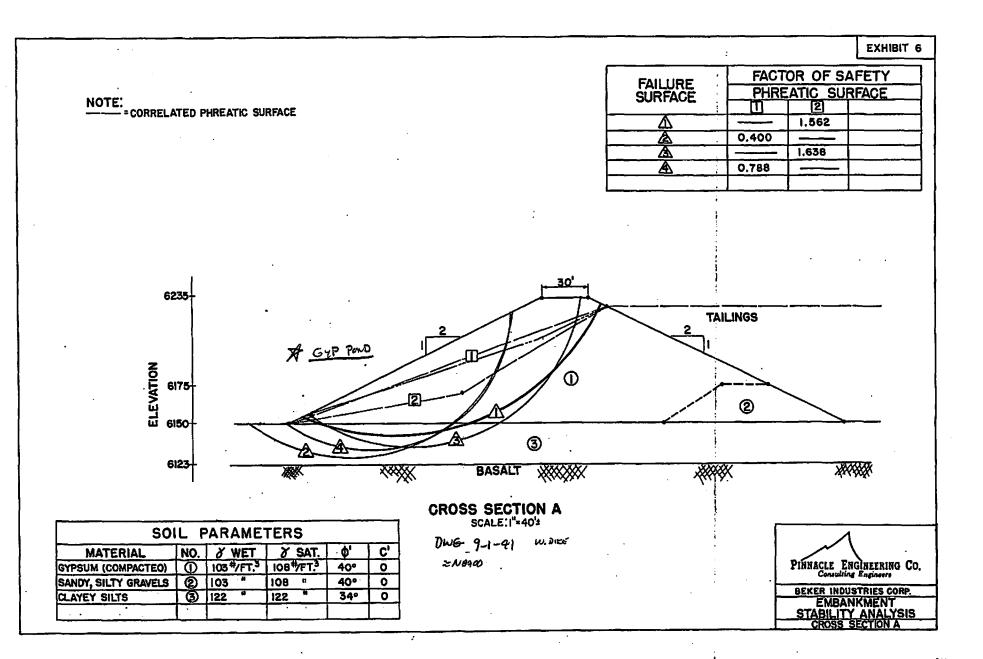


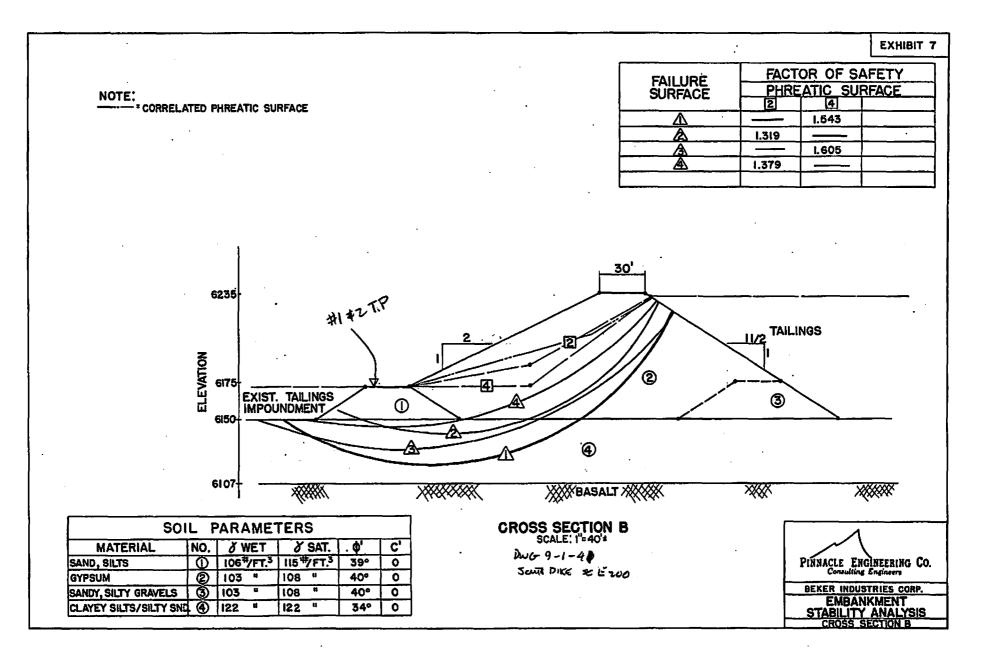


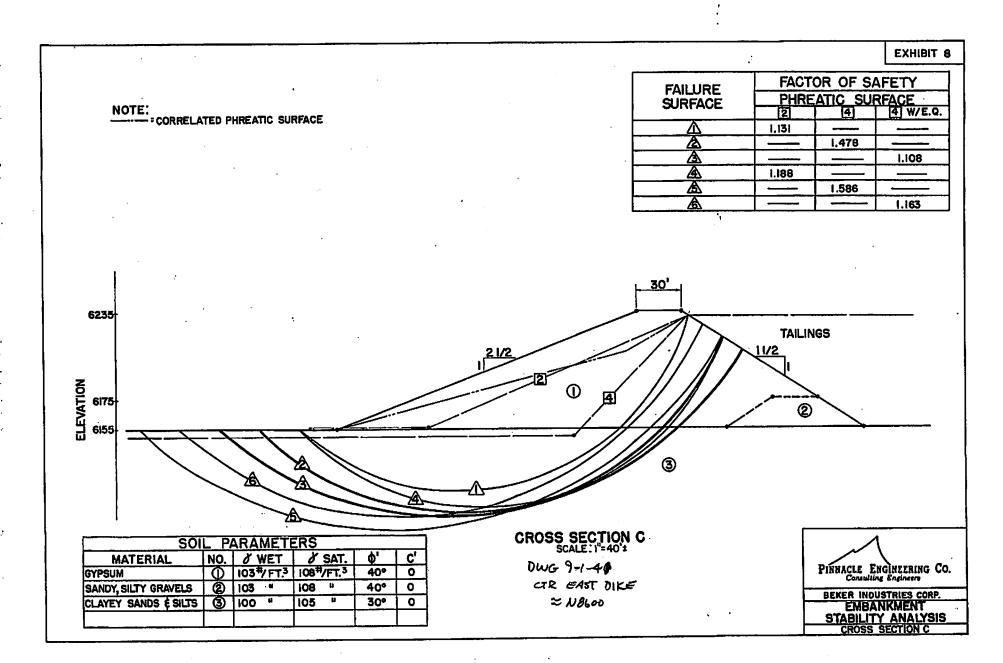












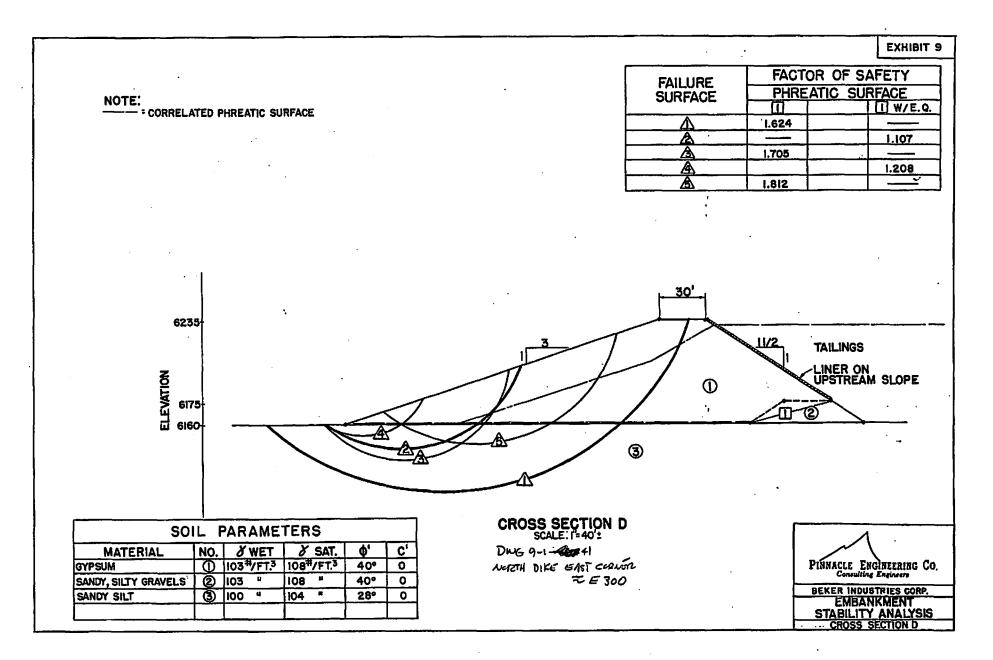
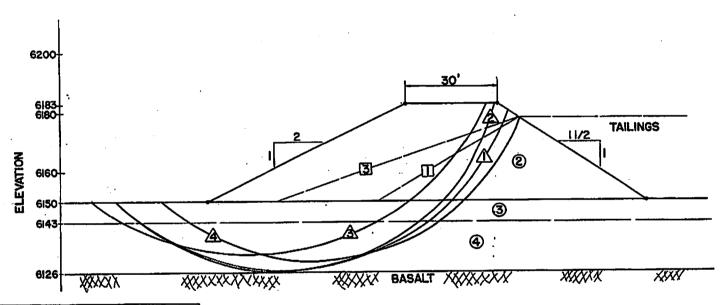


EXHIBIT II FACTOR OF SAFETY FAILURE SURFACE PHREATIC SURFACE 3 W/E.Q. 3 1.596 Δ 1.148 ⋬ 1.601 1.225 30¹ 6190 6183 **TAILINGS** ELEVATION 6117 SOIL PARAMETERS CROSS SECTION D & WET & SAT. C' NO. MATERIAL (2) 100.6[#]/FT.³ 100.6[#]/FT.³ 330 0,4 PINHACLE ENGINEERING CO. SANDY SILTY GRAVELS · Due 9-1-40 1985 EUNST. 3 100.0 " SANDY SILT 104.0 0 N. DIKK E. CURNET & E300 BEKER INDUSTRIES CORP.
EMBANKMENT
STABILITY ANALYSIS
SECOND PHASE (4) 100,0 30° 0 SILTY GRAVEL 105.0

EXHIBIT 12

FAILURE SURFACE	FACTOR OF SAFETY PHREATIC SURFACE			
	Δ	1.652		
A	T	1.468	•	
A	1.749			
A		1.520		
•				



MATERIAL	NO.	& WET	& SAT.	Φ'	C'
SANDY, SILTY GRAVELS	2	100.6 [#] /FT. ³	100.6 [#] /FT. ⁵	33°	0.4
SILTY SAND	(3)	115.0 "	115.0 "	35°	0
CLAYEY SILT	(4)	110,0	110.0	28°	0

CROSS SECTION F
SCALE: 1"=20"

DING 9-1-40 1925" CONTT.
SOUTH DIKE = W800

PINHACLE ENGINEERING CO.
Consulting Engineers

BEKER INDUSTRIES CORP.

EMBANKMENT
STABILITY ANALYSIS
SECOND PHASE

EXHIBIT 13 FACTOR OF SAFETY FAILURE SURFACE PHREATIC SURFACE m 3 W/E.Q. [3] 1.622 1.519 1.151 . 1.688 1.589 1.205 30 6183 TAILINGS 6170-ELEVATION 6151 3 6134 XXXX XXXXX 78XXXX **** XXXXXX XXXXXX BASALT SOIL PARAMETERS CROSS SECTION G NO. & WET & SAT.
(2) 100.6[‡]/FT.⁵ 100.6[‡]/FT.⁵ MATERIAL PINNACLE ENGINEERING CO. SANDY, SILTY GRAVELS Due 9-1-40 ABST CONST 33° 0.4 CLAYEY, SANDY SILT (3) 28* 110.0 110.0 0 WIETH DIKE # W 1950

BEKER INDUSTRIES CORP.
EMBANKMENT
STABILITY ANALYSIS
SECOND PHASE

EXHIBIT 14 FACTOR OF SAFETY FAILURE SURFACE PHREATIC SURFACE 1.489 1.619 1.652 1.716 6205 ELEVATION **TAILINGS** 6155 CROSS SECTION C-STAGE Y SOIL PARAMETERS DUG 9-1-41 INIDEMEDIATE STAGE NO. & WET & SAT. C' Enst dike = N8600 MATERIAL ① 103 */FT.3 108 */FT.3 PINNACLE ENGINEERING CO. GYPSUM 40° 0 ② 103 " SANDY SILTY GRAVELS 108 40° 0 BEKER INDUSTRIES CORP.
EMBANKMENT
STABILITY ANALYSIS
INTERMEDIATE STAGE CLAYEY SANDS & SILTS 3 100 " 30* 105 0

APPENDIX



REPORT OF GEOLOGICAL RECONNAISSANCE TAILINGS POND NO. 4 CONDA, IDAHO

CONSULTING GEOTECHNICAL ENGINEERS

Northern Jesting Laboratories CONSULTING ENGINEERS

Geotechnical Engineering

Field and Laboratory Investigations
Engineering Analysis and Recommendations
Consultation

Great Falls Billings Montana - Boise Pocatello Idaho - Gillette Wyoming

370 Benjamin Lane P. O. Box 7867 Boise, Idaho 83707 (208) 377-2100

3 February 1981

Beker Industries P.O. Box 37 Conda, Idaho 83203

Attention: Robert Hitt, P.E.

Subject:

Geological Reconnaissance

Tailings Pond No. 4

Gentlemen:

At your request and in accordance with our proposal dated May 12, 1980, we have made a geological reconnaissance at the site of the proposed No. 4 Tailings Pond at your C.F. White Plant in Conda, Idaho. The report which follows describes our investigations and summarizes our findings.

In general, the site geology consists of lake-deposited silt and clay over basalt bedrock.

If you have any questions regarding this report, or if we can be of further service, please contact us at your convenience.

Richard T. Kanemasu, P.

Dee J. Burrie, P.E.

RTK/DJB/rk Enclosure In quadruplicate